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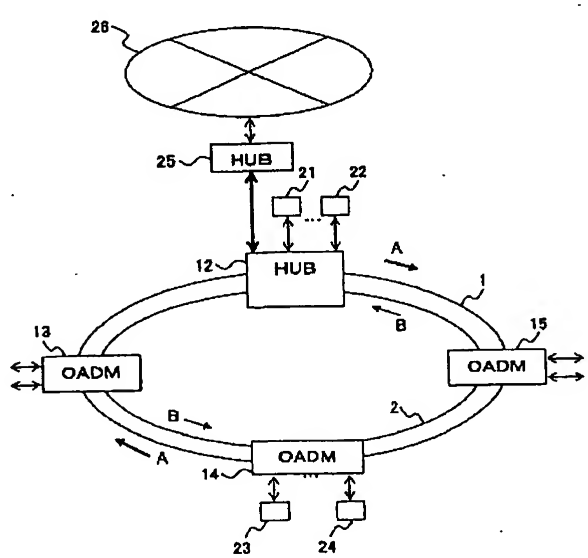
(54) An optical transmission apparatus and an optical wavelength multiplex network therewith

(57) A double-ring optical wavelength multiplex network is disclosed, which includes multiple optical transmission apparatuses that can reduce the unit cost of initially installing a small optical network while providing the flexibility to expand. For multiplexed optical signals arriving at a node, the optical transmission apparatus "drops" selected wavelengths for local delivery and "passes" others for continued transmission on the network. For optical signals originating ("added") at the node, the optical transmission apparatus wavelength multiplexes the "added" signals with the "passing" signals for transmission on the network. For "added" signals, the optical transmission apparatus blocks "passing" signals of the same wavelength.

FIG.1



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part will become apparent from the description and the accompanying drawings, or may be learned by practice of the invention according to the teachings provided in the description. Objects as well as other features and advantages of the present invention will be realized and attained by the optical transmission apparatus and the optical wavelength multiplex network therewith particularly pointed out in the specification in such full, clear, concise, and exact terms as to enable a person having ordinary skill in the art to practice the invention.

[0014] To achieve these and other advantages and in accordance with the purpose of the invention, as embodied and broadly described herein, the invention provides an optical transmission apparatus that reduces initial cost, and realizes a flexible network configuration and an optical wavelength multiplex network that employs the optical transmission apparatus.

[0015] In order to solve the above-mentioned problem, the present invention provides means as follows.

[0016] The optical transmission apparatus having an optical add/drop function for an optical wavelength multiplex network according to the present invention includes an optical branching (dropping) coupler for dividing wavelength multiplexed optical signals that are input into a wavelength multiplexed optical signal, which is called a passing signal, and another wavelength multiplexed optical signal, which is called a dropping signal, a filter for extracting an optical signal of a predetermined wavelength from the dropping signal, a laser for generating an optical signal of a wavelength (insertion wavelength) to be inserted by the optical transmission apparatus concerned, a blocking filter for blocking a wavelength contained in the passing signal, the wavelength to be blocked being the same as the insertion wavelength, and an optical coupler for coupling the optical signal of the insertion wavelength and the passing signal that passes through the blocking filter.

[0017] The blocking filter and the optical coupler may be replaced with a filter that is capable of serving the functions of the blocking filter and the optical coupler.

[0018] The filter for extracting an optical signal of a predetermined wavelength from the dropping signal is one of a fixed wavelength filter and a variable wavelength filter.

[0019] The present invention further includes an optical wavelength multiplex network that includes the optical transmission apparatus as described above, and is characterized by a double ring configuration having a HUB.

[0020] The optical transmission apparatus according to the present invention realizes a low initial cost, and further provides a flexible network configuration.

[0021] Further, where a filter that is capable of serving the functions of a blocking filter and an optical coupler is employed, according to the present invention, optical attenuation of the transmitted optical signal in the optical transmission apparatus can be made small, since one device (the filter) serves as the filter for inserting an optical signal to the transmission line, and the blocking filter for preventing the inserted optical signal from propagating more than a round on the transmission-line ring.

[0022] Since the optical wavelength multiplex network of the present invention is configured as a double ring network that has a HUB, the network offers high reliability, providing a protection function when a fault takes place.

[0023] According to the configuration of the present invention, all wavelength multiplexed optical signals are branched by the optical branching coupler, and a desired optical signal is extracted, so that wavelength allocation to each optical transmission apparatus in the network is dispensed with.

[0024] Further, since all the wavelengths of the network are branched, and a desired wavelength is selected, a common wavelength can also be selected by two or more nodes in the network such that an optical signal can be broadcast in the network.

[0025] Further, although the optical branching coupler passes selected wavelengths, the blocking filter blocks an optical signal having the same wavelength as an inserted optical signal, thereby cross talk of the optical signals is prevented from occurring.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026]

Fig. 1 is a schematic diagram of an example of a network;

Fig. 2 is a schematic diagram of a first example of an optical transmission apparatus that has an optical add/drop function;

Fig. 3 is a schematic diagram of a second example of an optical transmission apparatus that has the optical add/drop function;

Fig. 4 is a schematic diagram of an example of an optical transmission apparatus using AOTF;

Fig. 5 is a schematic diagram of an example of a network, where a wavelength group is assigned to each node;

Fig. 6 shows how communications are accomplished in the network shown in Fig. 5;

Fig. 7 shows how branching and inserting are carried out for each wavelength group;

Fig. 8 is a schematic diagram of an example of a HUB that includes an optical add/drop multiplexer and an optical switch;

Fig. 9 is a schematic diagram of an example of a HUB that includes an optical filter and an optical group filter;

Fig. 10 is a schematic diagram of an example of a HUB that includes an optical add/drop multiplexer and a MEMS; and

Fig. 11 is a block diagram for explaining the case where a rejection filter and an optical coupler for adding a wavelength are independently arranged.

wavelength is the same as an inserted wavelength. This is necessary because the inserted wavelength should not agree with any of the wavelengths that are to be further passed through, and because the inserted wavelength should be prevented from propagating beyond a round on the loop transmission line ring.

[0039] The rejection/add filter 331 is also for inserting (add) an optical signal to the transmission line, in addition to preventing the inserted wavelength from propagating beyond one round on the ring transmission line. Accordingly, attenuation of the optical signals caused by the optical transmission apparatus is minimized.

[0040] Here, if the optical attenuation of the transmitted optical signals in the optical transmission apparatus is not a great concern, a rejection filter 3311 and an optical coupler 3312 for inserting an optical signal to a transmission line may be independently provided as shown by Fig. 11.

[0041] Next, operations of the optical transmission apparatus shown by Fig. 2 are explained. Optical signals from West are input into the upward transmission unit 30. The optical signals input into the upward transmission unit 30 are supplied to the optical branching coupler 321, and divided into the passing signal that is to be passed through, and the dropping signal that is to be dropped. The passing signal that is branched by the optical branching coupler 321 is provided to the rejection/add filter 331, an optical signal having the same wavelength as an insertion wavelength is blocked, an optical signal to be inserted is added, an optical signal for surveillance is added by the supervisory-control-signal insertion filter 332, and a newly configured optical signal is output from the upward transmission unit 30.

[0042] The dropping signal is branched by the optical branching coupler 321 of the upward transmission unit 30. The supervisory-control-signal extraction filter 322 extracts a supervisory-control optical signal (OSC) from the dropping signal. The extracted supervisory-control optical signal contains an optical signal for carrying out surveillance and control of the optical transmission apparatus, the optical transmission line, and so on.

[0043] The dropping signal from which the supervisory-control optical signal is extracted is amplified by the WDM preamplifier 323, and is split by the 1x4 couplers 324, and provided to the variable wavelength filters 325 through 328, each of which extracts an optical signal of a respective predetermined wavelength to be dropped. An optical signal destined for the optical transmission apparatus concerned passes the variable wavelength filter 325, and is monitored by the monitor 38. Similarly, the optical signal transmitted by the optical transmission line 11 from East, and destined for the optical transmission apparatus concerned is monitored by the monitor 39.

[0044] Based on the output of the monitors 38 and 39, the selector 37 selects one of the optical signals destined for the optical transmission apparatus concerned, and the selected optical signal for the optical transmission apparatus concerned is provided to the optical receiver OR 41.

[0045] In this example, the optical signals extracted by the variable wavelength filters 325 through 328 are provided to user terminals, and the like.

[0046] Next, an explanation is made as to how an optical signal is inserted by the insertion unit 33, and transmitted from the upward transmission unit 30 prepared in the optical transmission line 10 that transmits signals from West to East.

[0047] The optical signal from the optical transmitter OS 40 is provided to the 1x2 coupler 36, then to the single wave amplifier 338, which amplifies the optical signal, and then to the 4x1 coupler 334. Optical signals of the fixed wavelength lasers 42, 43, and 44 are modulated by respective signals from the user terminals, and the like, amplified by the single wave amplifiers 335 through 337, and supplied to the 4x1 coupler 334.

[0048] The 4x1 coupler 334 bundles the inserted optical signals. The WDM amplifier 333 amplifies the bundled optical signal. The rejection/add filter 331 further bundles the bundled optical signal and the passing signal that is branched by the optical branching coupler 321. The further bundled optical signal is passed through the supervisory-control-signal insertion filter 332, and transmitted to the optical transmission line 10 serving communications from West to East. Here, the WDM amplifier 333 is not essential, and can be eliminated.

[0049] In this manner, the optical transmission apparatus having the optical add/drop function for the wavelength multiplex network according to the present invention includes the optical branching coupler 321 for dividing the input wavelength multiplexed optical signals into the passing signal and the dropping signal, the variable wavelength filters 325-328 for extracting the optical signals of the predetermined wavelengths from the dropping signal, the fixed wavelength lasers 42-44 for generating the optical signals to be inserted by the optical transmission apparatus concerned, the rejection filter 331 for blocking the optical signal of the same wavelength as the insertion wavelength from the passing signal, and the optical coupler 331 for coupling the passing signal and the inserted optical signal that is inserted at the insertion wavelength. In this manner, the optical path connection between desired nodes is established.

[0050] That is, the optical path connection between desired nodes is attained by branching a desired wavelength out of the wavelength signals transmitted.

[0051] Further, the optical attenuation of the transmitted optical signal in the optical transmission apparatus is reduced by using the rejection/add filter 331 that functions as a blocking filter for blocking an optical signal having the same wavelength as the insertion wavelength, and as an optical coupler for coupling the optical signal of insertion wavelength and the passing signal that is branched by the optical branching coupler.

the configurations shown by Fig. 2 and Fig. 3, an optical path can be provided as desired by provisioning.

[0065] Further, according to the embodiment having the configurations shown by Fig. 2 and Fig. 3, the insertion loss of the optical signal that is passed through the node is minimized, and an in-line amplifier can be eliminated, reducing the network cost.

[0066] Further, according to the embodiments shown by Fig. 2 and Fig. 3, the configuration can be changed and upgraded according to the required number of wavelengths, providing a low initial cost when a small number of wavelengths are initially installed.

[0067] Further, according to the configurations shown by Fig. 2 and Fig. 3, even in the case that the number of wavelengths is 32 or smaller, the initial cost is lowered, and, further, the network configuration is flexible.

[0068] Here, various kinds of variable wavelength filters can be used as the variable wavelength filters 325 through 328 of the configuration shown by Fig. 2.

[0069] Fig. 4 shows an example, wherein an AOTF (Acousto-Optic Tunable Filter) 329 is employed as the variable wavelength filters 325 through 328.

[0070] The AOTF 329 selects an optical wavelength by an RF signal (electrical signal) being applied, the RF signal corresponding to the wavelength that is to be dropped. For example, when the wavelength multiplex optical signal containing wavelengths λ_1 through λ_n is input into the AOTF 329, and if the wavelengths λ_1 through λ_4 are to be extracted from the wavelengths λ_1 through λ_n, RF signals having frequencies f_1 through f_4 corresponding to the wavelengths λ_1 through λ_4, respectively, are applied to the AOTF 329.

[0071] Similarly, as the variable wavelength filters 325 through 328, a dielectric multilayer filter, a FGB (optical fiber Bragg-diffraction grid) type filter, and a Fabry-Perot type filter can be used.

(Wavelength group)

[0072] Fig. 5 shows an example of the network configuration, wherein a wavelength group (for example, a group of four wavelengths) is assigned to each node. The network shown at (A) of Fig. 5 includes an optical loop circuit 69, a HUB 70, and optical transmission apparatuses (nodes) 72 through 77. Here, two or more wavelength groups may be assigned to each of the optical transmission apparatuses 72 through 77.

[0073] Each of the HUB 70 and the optical transmission apparatuses 72 through 77 branches (drops) and adds (inserts) optical signals transmitted in the optical loop circuit 69 based on the wavelength group, i.e., in units of wavelength groups, thereby providing communications between the HUB 70 and the optical transmission apparatuses 72 through 77, and communications between the optical transmission apparatuses 72 through 77. In this manner, communications are provided between user terminals connected to the HUB 70 and the optical transmission apparatuses 72 through 77.

[0074] The wavelength groups are defined as shown at (B) of Fig. 5, each wavelength group including four wavelengths in the present example. Group 1 includes the wavelengths λ_1 through λ_4, Group 2 includes the wavelengths λ_5 through λ_8, and so on up to Group 7 that includes the wavelengths λ_{25} through λ_{28}. Although an illustration is omitted, Group 8 including wavelengths λ_{29} through λ_{32} is assigned to the HUB 70. Each wavelength has an interval of 100 GHz. In addition, an insertion wavelength can be selected as desired, not limited to the plan of the present example.

[0075] As shown at (A) of Fig. 5, the optical transmission apparatuses 71 through 77 are set up so that the Groups 1 through 7, respectively, are inserted. Further, the HUB 70 can branch and insert all the Groups.

[0076] That is, the wavelengths to be inserted are fixed to each of the optical transmission apparatuses 71 through 77; however, the optical transmission apparatuses 71 through 77 can branch (drop) any wavelength as desired.

[0077] Communication modes of the network shown by Fig. 5 are explained using Fig. 6. At (A) of Fig. 6, communications are carried out from the HUB 70 to each of the nodes (the optical transmission apparatuses 71 through 77), using four wavelengths per node. Here, the HUB 70 transmits optical signals at the wavelengths assigned to Group 1, Group 2, and up to Group 7, which are received by the nodes 71, 72 and up to 77, respectively.

[0078] At (B) of Fig. 6, communications are carried out to the HUB 70 from each of the nodes 71, 72 and up to 77, each node using four wavelengths. Here, the nodes 71, 72 and up to 77 transmit optical signals at the wavelengths assigned to Group 1, Group 2 and up to Group 7, respectively. The HUB 70 receives all the optical signals transmitted by the wavelengths of all the Groups.

[0079] At (C) of Fig. 6, the case is shown where communications between each node and the HUB and between the nodes are carried out. In this example, the HUB 70 communicates with the node 72 by the HUB 70 transmitting optical signals at the wavelengths assigned to Group 8, and receiving optical signals at the wavelengths assigned to Group 2; and the node 72 receiving the optical signals at the wavelengths assigned to Group 8, and transmitting the optical signals at the wavelengths assigned to Group 2. Further, in this example, the node 77 communicates with the node 72 by the node 77 transmitting optical signals at the wavelengths assigned to Group 7, and receiving optical signals at the wavelengths assigned to Group 2; and the node 72 receiving the optical signals at the wavelength assigned to Group 7, and transmitting the optical signals at the wavelength assigned to Group 2.

[0080] At (D) of Fig. 6, the case where broadcasting communications are carried out from the HUB 70 to each node is shown. An optical signal at a wavelength assigned to Group 8 is transmitted from the HUB 70, and is received by the nodes 71 through 77.

switches 109, 110, and 111. The other of the divided optical signals is provided to the downward transmission line (from East to West) via the 2x1 switches 209, 210, and 211.

[0091] The optical signal received from the upward transmission line is provided to the 2x1 switch 115 through the 1x2 couplers 106, 107, and 108. Further, the optical signal received from the downward transmission line is provided to the 2x1 switch 115 through the 1x2 couplers 206, 207, and 208. Then, the 2x1 switch 115 selects one of the upward and downward transmission lines for receiving the optical signal, and the selected optical signal is received by the optical receiver 116.

[0092] In this manner, the 2x1 switch 115 is controlled such that use of a faulty transmission line is avoided based on the monitoring result, and communications are provided using a normal transmission line.

[0093] Here, the 1x2 couplers 106, 107, and 108 and 1x2 couplers 206, 207, and 208 may be replaced with 2x1 switches, and the 2x1 switch 115 may be replaced with a 2x1 coupler.

[0094] In this manner, each optical transmission apparatus can operate using one of the transmission lines as an operating circuit, while the other transmission line serves as the standby circuit. Further, when a circuit or an optical transmission apparatus becomes faulty, the above configuration allows communications to continue by avoiding the faulty circuit or faulty optical transmission apparatus, reducing the influence due to the fault to a minimum. Accordingly, the 1x2 couplers 106, 107, and 108, 1x2 couplers 206, 207, and 208, and the 2x1 switch 115 constitute a protection unit.

[0095] Fig. 9 shows an example of a HUB that includes an optical filter and an optical group filter. The HUB includes an upward transmission unit 128, a downward transmission unit 129, monitors 140 and 141 each monitoring a single wavelength, 1x2 couplers 143, 147, and 150, 2x1 switches 142, 146, and 149, an optical receiver 148, and an optical transmitter 144.

[0096] The upward transmission unit 128 includes a tee 130 and an insertion unit 131. The tee 130 includes optical group filters 132, 133, and 134 for extracting wavelengths of a predetermined wavelength group. The insertion unit 131 includes optical group filters 135, 136, and 137 for inserting wavelengths of a predetermined wavelength group, and for blocking wavelengths that are the same as the wavelengths of the predetermined wavelength group.

[0097] Further, the optical group filter 134 for extracting wavelengths of a predetermined wavelength group includes a wavelength group filter 1341 for extracting the wavelengths of the predetermined wavelength group, and single wavelength filters 1342 through 1345, each extracting a single wavelength. Other optical group filters 132 and 133 are configured the same as the optical group filter 134.

[0098] Further, the optical group filter 137 for inserting wavelengths, and for blocking the same wavelengths as the wavelengths that are inserted includes a wavelength group filter 1371 for inserting the wavelengths, and for blocking the same wavelengths as the wavelengths inserted, and single wavelength filters 1372 through 1375, each inserting and blocking a single wavelength. Other optical group filters 135 and 136 are configured the same as the optical group filter 137.

[0099] In this manner, the same functions as the HUB shown by Fig. 8 are obtained.

[0100] Fig. 10 shows an example of a HUB that includes an optical demultiplexer, an optical multiplexer, and a MEMS (Micro Electro-Mechanical Systems) switch. The HUB includes WDM amplifiers 170, 174, 270, and 274 for amplifying wavelength multiplexed optical signals, optical demultiplexers 171 and 271, MEMS switches 172 and 272, optical multiplexers 173 and 273, monitors 175 and 275 for monitoring optical signals in units of wavelengths, 1x2 couplers 176 and 276, filters 177 and 277 for extracting monitoring signals, a 2x1 switch 180, an optical transmitter 179, and an optical receiver 181.

[0101] In this manner, the same functions as the configuration shown by Fig. 8 are obtained.

[0102] As described above, the present invention provides the optical transmission apparatus, and the optical wavelength multiplex network employing the optical transmission apparatus that reduce the initial cost, and are flexible in network configuration.

[0103] Further, the present invention is not limited to these embodiments, but various variations and modifications may be made without departing from the scope of the present invention.

[0104] The present application is based on Japanese priority application No. 2003-019067 filed on 1, 28, 2003 with the Japanese Patent Office, the entire contents of that are hereby incorporated by reference.

Claims

1. An optical transmission apparatus with an optical add/drop function used in an optical wavelength multiplex network, comprising:

   an optical branching coupler for dividing an input wavelength multiplexed optical signal into a wavelength multiplexed optical signal, which is called a passing signal, and another wavelength multiplexed optical signal, which is called a dropping signal,
   a filter for extracting a first optical signal at a predetermined wavelength from the dropping signal that is branched by the optical branching coupler,
   a laser for generating a second optical signal that is to be inserted,
   a blocking filter for blocking a third optical signal contained in the passing signal that is branched

FIG.1

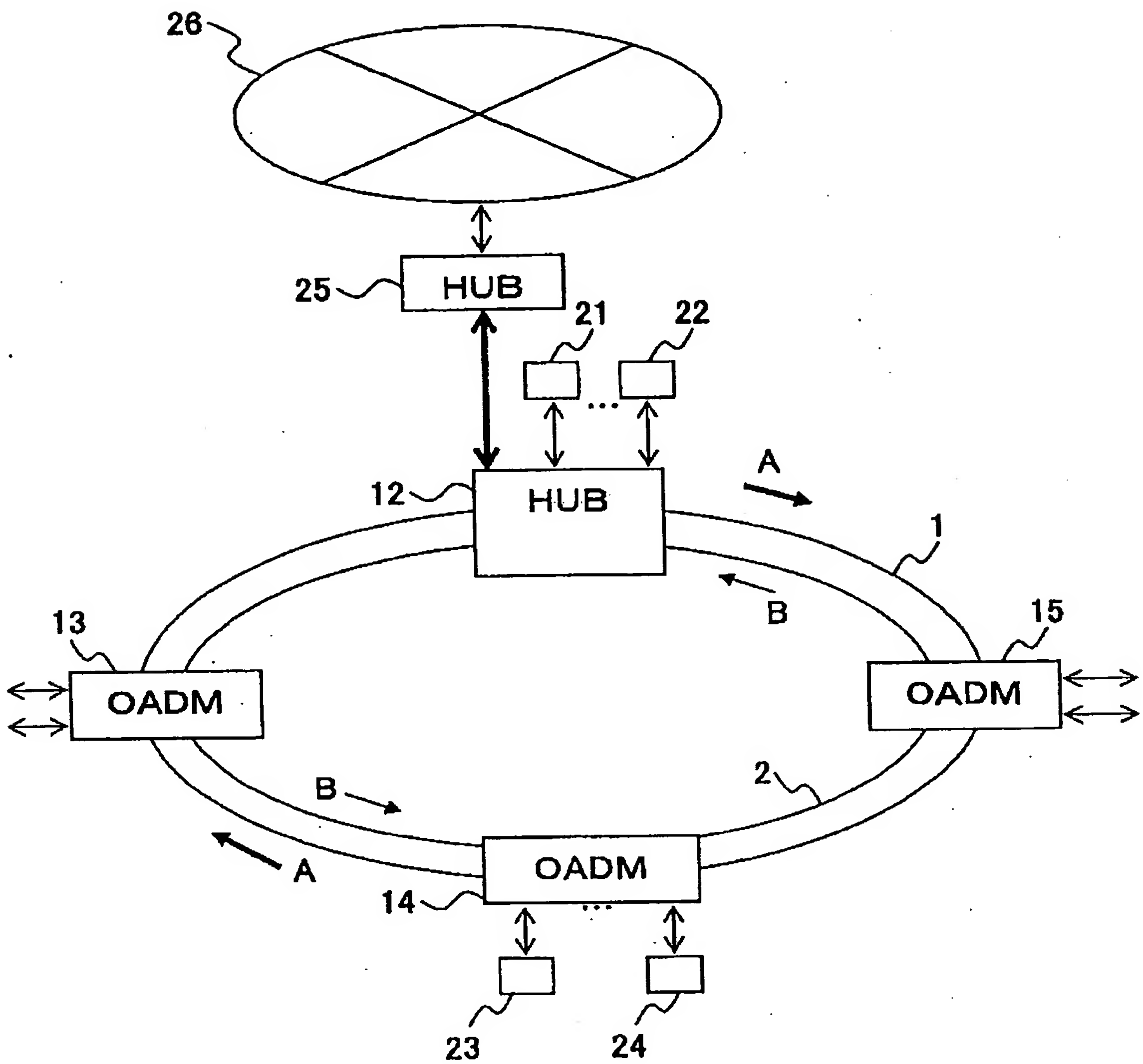


FIG.3

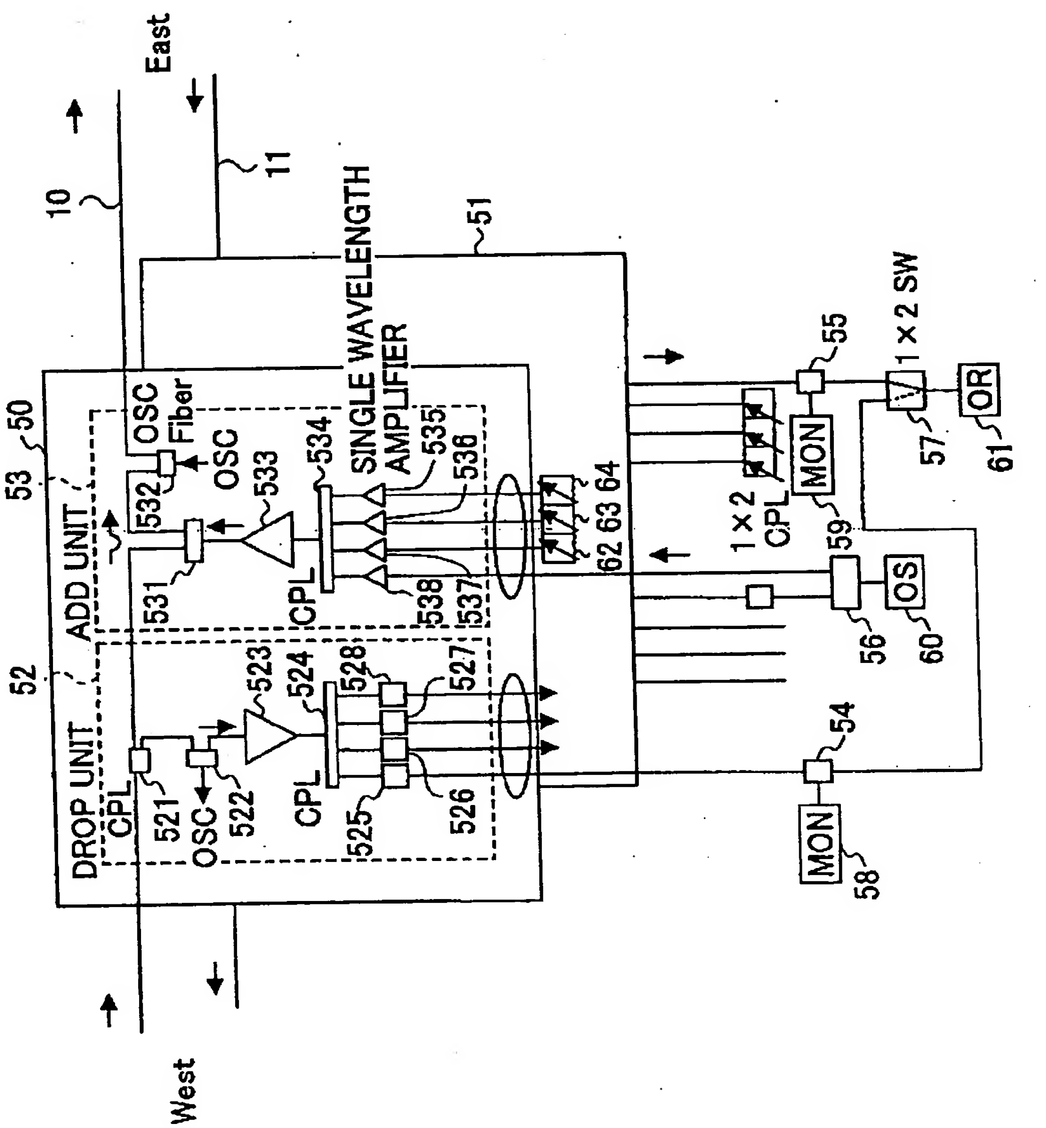

East
West
10
11
51
50
53
52
ADD UNIT
DROP UNIT
OSC
Fiber
OSC
532
531
533
534
CPL
SINGLE WAVELENGTH
AMPLIFIER
535
536
537
538
CPL
521
OSC
522
523
524
CPL
525
526
527
528
62 63 64
1×2
CPL
MON
59
55
1×2 SW
57
OR
61
56
OS
60
54
MON
58

FIG.5

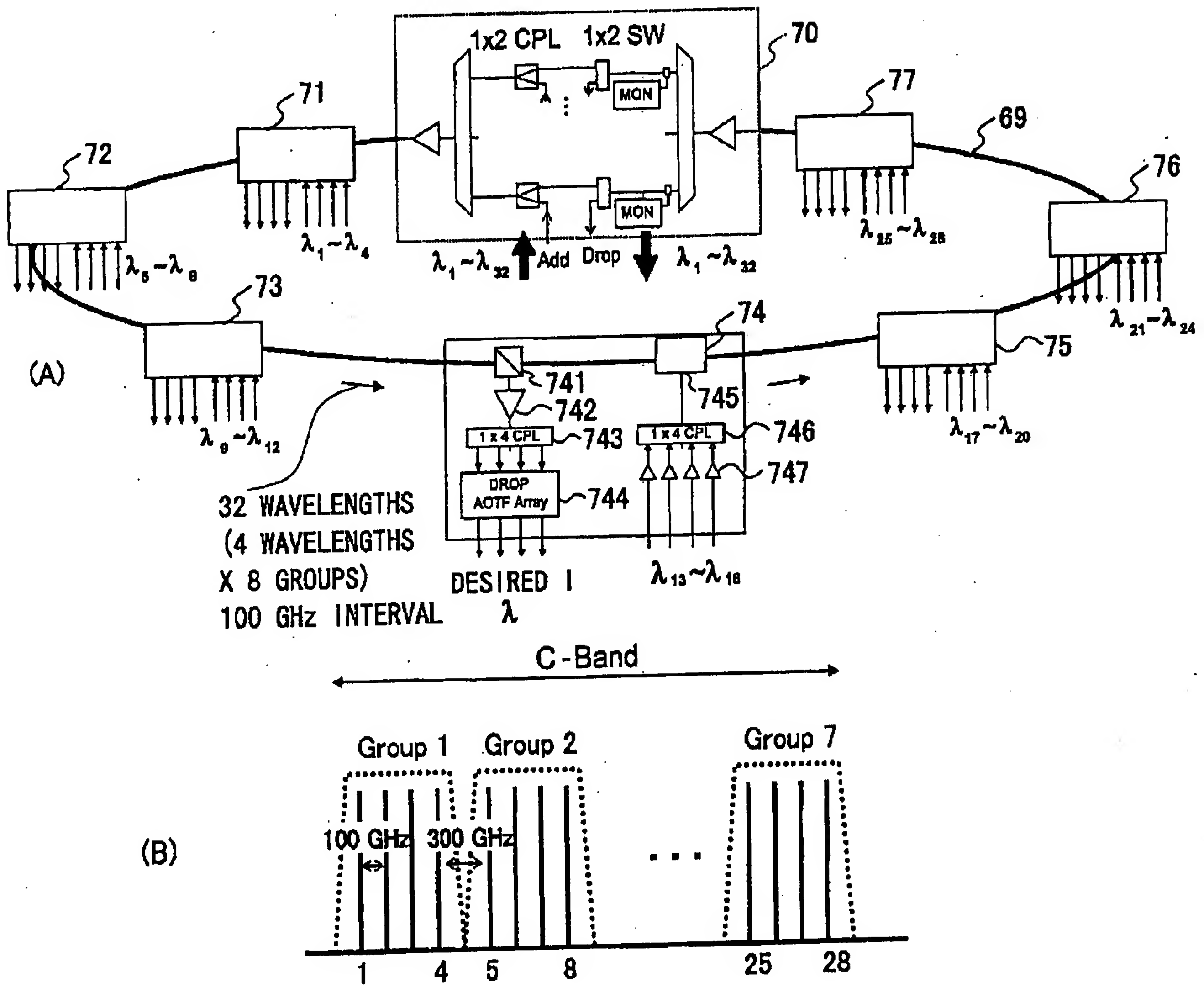

1x2 CPL
1x2 SW
MON
MON
70
71
72
73
74
75
76
77
69
λ_1~λ_4
λ_5~λ_8
λ_9~λ_{12}
λ_{13}~λ_{16}
λ_{17}~λ_{20}
λ_{21}~λ_{24}
λ_{25}~λ_{28}
λ_1~λ_{32}
Add
Drop
λ_1~λ_{32}
741
742
1x4 CPL
743
DROP AOTF Array
744
745
1x4 CPL
746
747
(A)
32 WAVELENGTHS
(4 WAVELENGTHS
X 8 GROUPS)
100 GHz INTERVAL
DESIRED λ
C-Band
(B)
Group 1
Group 2
Group 7
100 GHz
300 GHz
...
1
4
5
8
25
28

FIG.7

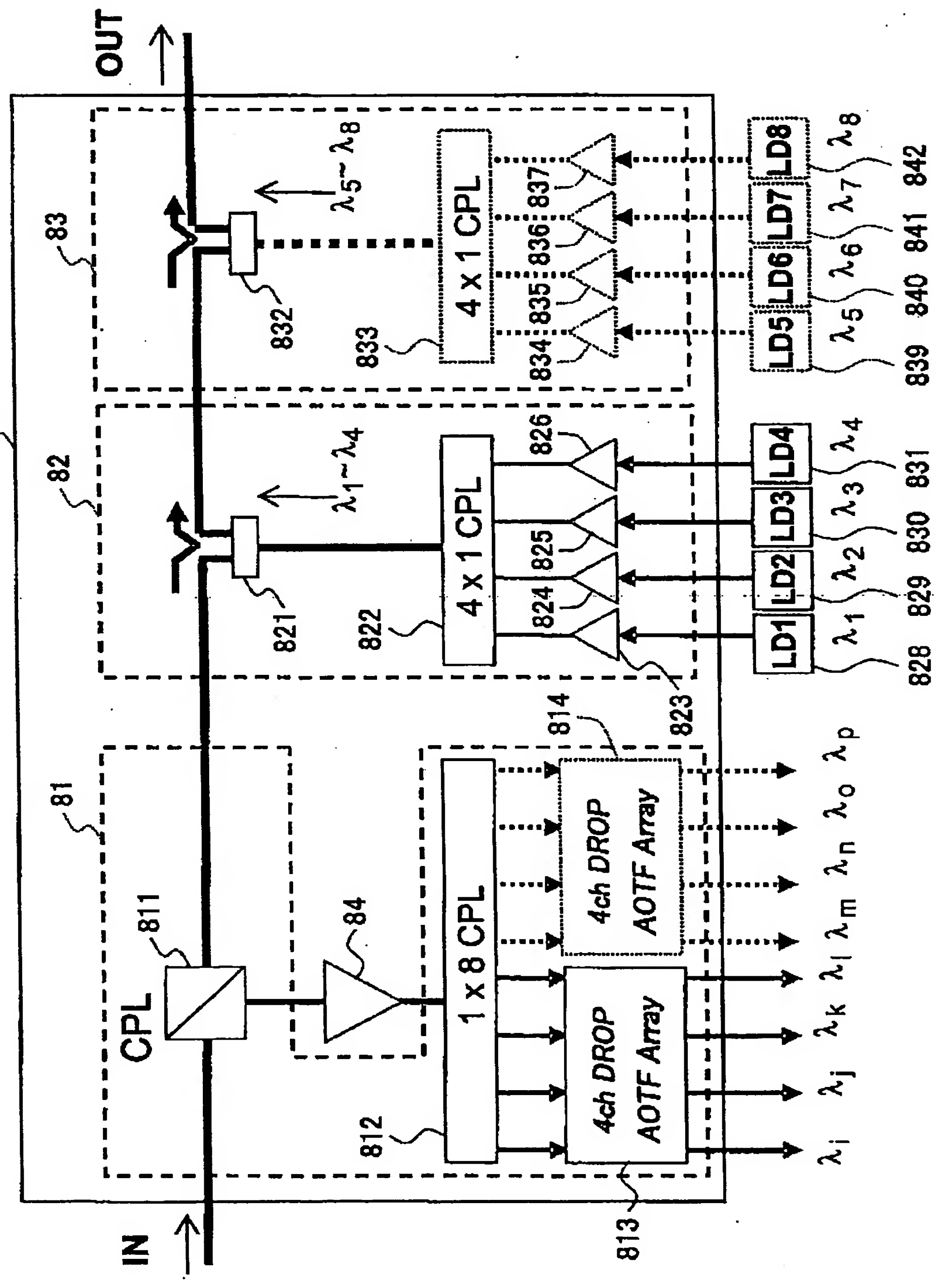
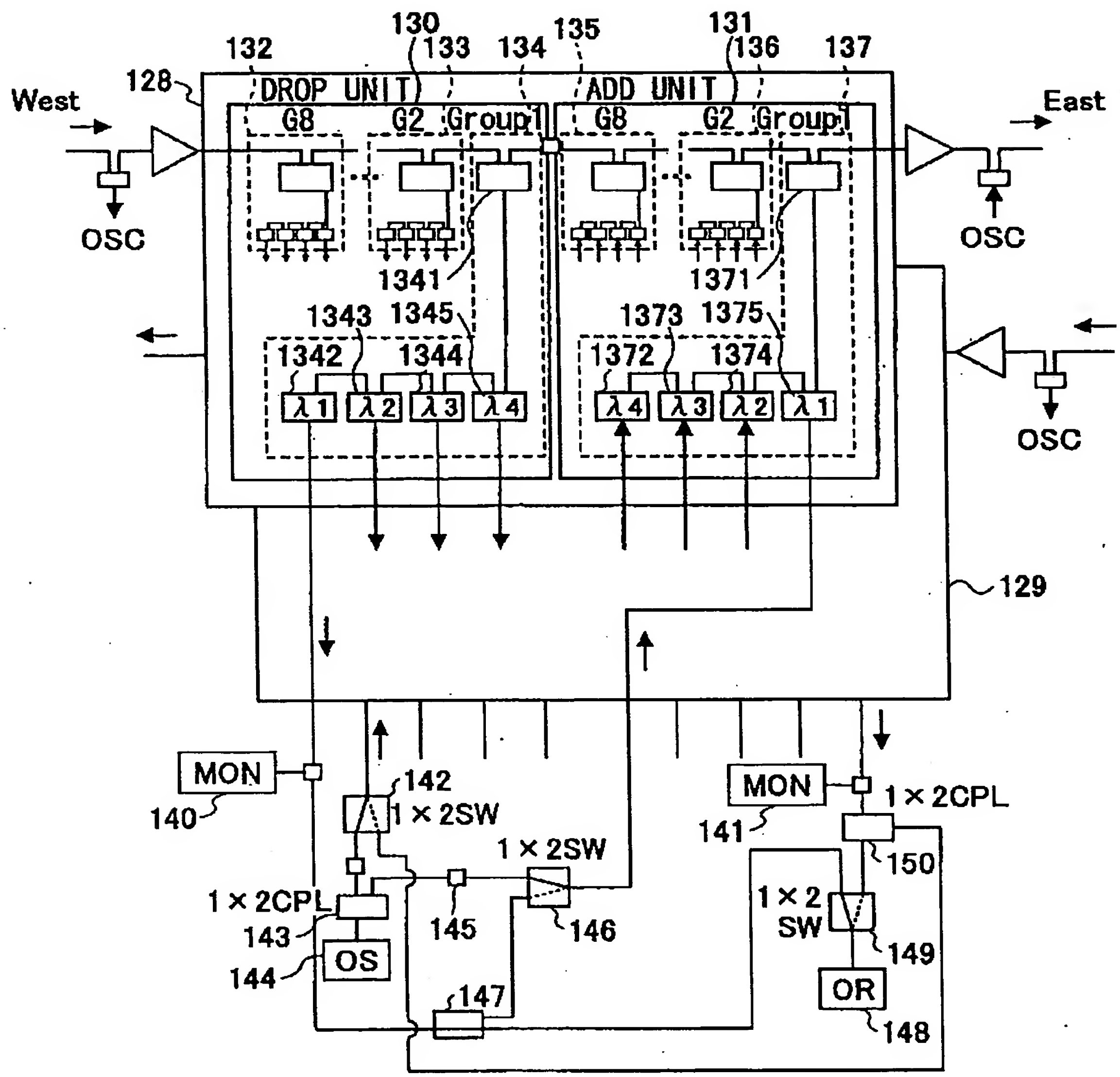
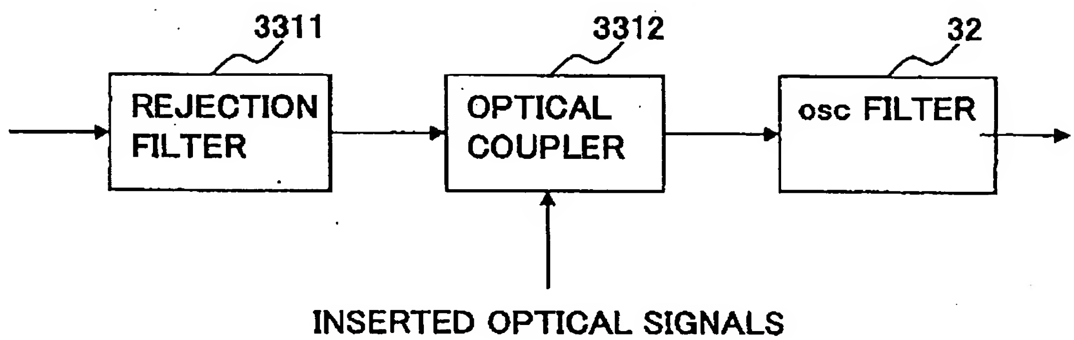

IN
OUT
80
81
CPL
811
812
813
814
84
1 x 8 CPL
4ch DROP AOTF Array
4ch DROP AOTF Array
λ_i λ_j λ_k λ_l λ_m λ_n λ_o λ_p
82
821
822
823
824
825
826
4 x 1 CPL
$\lambda_1 \sim \lambda_4$
LD1 LD2 LD3 LD4
λ_1 λ_2 λ_3 λ_4
828 829 830 831
83
832
833
834 835 836 837
4 x 1 CPL
$\lambda_5 \sim \lambda_8$
LD5 LD6 LD7 LD8
λ_5 λ_6 λ_7 λ_8
839 840 841 842

FIG.9



West
East
128
130
131
132
133
134
135
136
137
DROP UNIT
ADD UNIT
G8
G2
Group1
OSC
OSC
OSC
1341
1343
1345
1342
1344
1371
1373
1375
1372
1374
λ1
λ2
λ3
λ4
λ4
λ3
λ2
λ1
129
MON
140
142
1×2SW
1×2CPL
143
OS
144
145
1×2SW
146
147
MON
141
1×2CPL
150
1×2
SW
149
OR
148

FIG.11


3311
3312
32
REJECTION FILTER
OPTICAL COUPLER
osc FILTER
INSERTED OPTICAL SIGNALS